


**VERIFICATION OF TRANSLATION**

Re: Japanese patent application No. 2001-36260

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hereby declare that I am the translator of the  
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A handwritten signature in black ink, appearing to read 'Katsuaki Matsukawa', is written over a horizontal line.

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Date: November 11, 2003

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the following application as filed with this Office.

Date of Application: February 14, 2001

Application Number: 2001-36260

Applicant(s): Sanyo Electric Co., Ltd.

[Name of Document]                      Application for Patent  
[Reference Number]                      NAA1001199  
[Filing Date]                              February 14, 2001  
[Destination]                              to Director General  
[International Class]                      H01M 10/40  
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[Fee Payment]

[Number of Advance Payment Ledger] 009656

[Application Fee for Patent] 21,000

[List of Contents]

[Document] Specification 1

[Document] Drawings 1

[Document] Abstract 1

[Assigned Number of Applicant to the Attorneys] 9401514

[Necessity of Proof] Yes

[Name of Document] Specification

[Title of the Invention] LITHIUM SECONDARY BATTERY

[Scope of Claim for Patent]

[Claim 1] A lithium secondary battery formed by placing at least a positive electrode, a negative electrode, and a non-aqueous electrolyte in a battery case in which a positive electrode connecting member to which the positive electrode is connected and a negative electrode connecting member to which the negative electrode is connected are electrically separated,

wherein said positive electrode connecting member is composed of clad material comprising one of aluminum or aluminum alloy and one of austenitic stainless steel or ferrite stainless steel, and the aluminum or aluminum alloy in the clad material is set in an inward side of the positive electrode connecting member.

[Claim 2] The lithium secondary battery according to claim 1, wherein

the aluminum or aluminum alloy in said clad material as the positive electrode connecting member is aluminum-manganese alloy.

[Claim 3] The lithium secondary battery according to one of claims 1 and 2, wherein

a nickel plating layer is formed on the austenitic stainless steel or the ferrite stainless steel in said clad material as the positive electrode connecting member.

[Claim 4] The lithium secondary battery according to one of claims 1 to 3, wherein

the austenitic stainless steel in said clad material is at least one of SUS316L, SUS316, SUS304L, and SUS304, and the ferrite stainless steel in said clad material is at least one of SUS430 and SUS434.

[Detailed Description of the Invention]

[0001]

[Applicable Industrial Field]

The present invention relates generally to a lithium secondary battery formed by placing at least a positive electrode, a negative electrode, and a non-aqueous electrolyte in a battery case wherein a positive electrode connecting member to which the positive electrode is connected and a negative electrode connecting member to which the negative electrode is connected are electrically separated, and is characterized in that the positive electrode connecting member to which the positive electrode is connected in the battery case is modified so as to improve storage characteristics of the lithium secondary battery.

[0002]

[Description of the Prior Art]

As a secondary battery having high power and high energy density, lithium secondary batteries featuring high electromotive force derived from oxidation / reduction of lithium in the non-aqueous electrolyte have come into wide use.

[0003]

Examples of such lithium secondary batteries include a coin-type lithium secondary battery prepared by sandwiching a separator 3 impregnated with non-aqueous electrolyte solution between a positive electrode adhered to a positive electrode current collector 5 and a negative electrode 2 adhered to a negative electrode current collector 6, placing said members in a battery case 10, then, connecting the positive electrode 1 to the positive electrode connecting member 11 in the battery case 10 via the positive electrode current collector 5 whereas connecting the negative electrode 2 to the negative electrode connecting member 12 via the negative electrode current collector 6, subsequently, providing an insulation packing 13 composed of polypropylene around the positive electrode connecting member 11 and the negative electrode connecting member 12, and bending the positive electrode connecting member 11 so as to seal the space between the

positive electrode connecting member 11 and the negative electrode connecting member 12 as shown in Fig. 1.

[0004]

In such lithium secondary battery, stainless steel or aluminum have been generally used as the positive electrode connecting member 11 in the battery case 10, and stainless steel has been generally used as the negative electrode connecting member 12 because aluminum gets alloyed with lithium when aluminum is used.

[0005]

In the above-mentioned lithium secondary battery, when the positive electrode connecting member 11 is composed of aluminum, there have remained problems that the positive electrode connecting member 11 can not be fully bent to seal the space between the positive electrode connecting member 11 and the negative electrode connecting member 12, thus moisture comes into the battery can 10 from the sealed portion, hence storage characteristics is degraded.

[0006]

On the other hand, when the positive electrode connecting member 11 is composed of stainless steel, there have remained problems that the stainless steel used as the positive electrode connecting member 11 corrodes away by the non-aqueous electrolyte solution. Especially, when



cobalt-lithium oxide, nickel-lithium oxide, or manganese-lithium oxide having a spinel structure is used as the positive electrode of the lithium secondary battery to obtain a lithium secondary battery having high voltage, the stainless steel used as the positive electrode connecting member 11 corrodes away more intensively, thus the storage characteristics of the lithium secondary battery is remarkably degraded.

[0007]

[Problems to be Solved]

An object of the present invention is to solve the above-mentioned various problems concerned with a lithium secondary battery formed by placing at least a positive electrode, a negative electrode, and a non-aqueous electrolyte in a battery case wherein a positive electrode connecting member to which the positive electrode is connected and a negative electrode connecting member to which the negative electrode is connected are electrically separated.

[0008]

In another word, an object of the present invention is, in such lithium secondary battery, to modify a positive electrode connecting member in order to bend the positive electrode connecting member properly and seal a space between the positive electrode connecting member and a

negative electrode connecting member sufficiently.

Additional object is to prevent the positive electrode connecting member from corroding away, thus to improve storage characteristics, even in a case in which cobalt-lithium oxide, nickel-lithium oxide, or manganese-lithium oxide having a spinel structure is used as the positive electrode to obtain the lithium secondary battery having high voltage.

[0009]

[Solution to the Problems]

To solve the above-mentioned problems, a lithium secondary battery according to the present invention is formed by placing at least a positive electrode, a negative electrode, and a non-aqueous electrolyte in a battery case in which a positive electrode connecting member to which the positive electrode is connected and a negative electrode connecting member to which the negative electrode is connected are electrically separated, wherein said positive electrode connecting member is composed of clad material comprising one of aluminum or aluminum alloy and one of austenitic stainless steel or ferrite stainless steel, and the aluminum or aluminum alloy in the clad material is set in an inward side of the positive electrode connecting member.

[0010]

As the above-mentioned lithium secondary battery, when the clad material comprising one of aluminum or aluminum alloy and one of austenitic stainless steel or ferrite stainless steel is used as the positive electrode connecting member, strength of the clad material is higher compared with the case where only aluminum is used, thus the positive electrode connecting member is properly bent in order to seal fully the space between the positive electrode connecting member and the negative electrode connecting member. As a result, moisture is prevented from coming into the battery can from a sealed portion, hence storage characteristics of the lithium secondary battery is improved.

[0011]

As the lithium secondary battery of the present invention, when the aluminum or aluminum alloy in the clad material is set in the inward side of the positive electrode connecting member, the positive electrode connecting member is prevented from corroding away by the non-aqueous electrolyte solution even in a case in which cobalt-lithium oxide, nickel-lithium oxide, or manganese-lithium oxide having the spinel structure is used for the positive electrode of the lithium secondary battery to obtain the lithium secondary battery having high voltage. Further, a resistant alloy is formed in the interface

between one of the aluminum or aluminum alloy and one of the austenitic stainless steel or ferrite stainless steel, thus even in the case where the aluminum or aluminum alloy set in the inward side of the positive electrode connecting member is damaged for the contact with the positive electrode current collector, the austenitic stainless steel or the ferrite stainless steel is prevented from corroding away by the non-aqueous electrolyte solution owing to the resistant alloy, hence storage characteristics of the lithium secondary battery is improved.

[0012]

When aluminum-manganese alloy is used as the aluminum or aluminum alloy in the clad material as the positive electrode connecting member, the alloy having superior resistance is formed in the interface between the aluminum manganese alloy and one of austenitic stainless steel or ferrite stainless steel, thus the austenitic stainless steel or the ferrite stainless steel is further prevented from corroding away by the non-aqueous electrolyte solution, hence the storage characteristics of the lithium secondary battery is further improved.

[0013]

Examples of the austenitic stainless steel in the clad material as the positive electrode connecting member include SUS316L, SUS316, SUS304L, SUS304, SUS201, SUS310S,

SUS321, SUS347, and SUSXM7, and at least one of SUS316L, SUS316, SUS304L, SUS304 is preferably used. Examples of the ferrite stainless steel include SUS430, SUS430F, and SUS434, and at least one of SUS430 and SUS434 is preferably used.

[0014]

The lithium secondary battery of the present invention is characterized in that the clad material comprising one of aluminum or aluminum alloy and one of austenitic stainless steel or ferrite stainless steel is used as the positive electrode connecting member to which the positive electrode is connected, and that the aluminum or aluminum alloy in the clad material is set in the inward side. The positive electrode, the negative electrode, and the non-aqueous electrolyte used in the lithium secondary battery are not especially limited, but well-known material which have been generally used can be used.

[0015]

[Embodiments]

The following examples specifically illustrate lithium secondary batteries of the present invention. Further, comparative examples will be taken to make it clear that storage characteristics of the lithium secondary batteries of the present invention is improved. It should be appreciated that the lithium secondary batteries of the

present invention are not particularly limited to those in the following examples, and various changes and modifications may be made in the invention without departing from the spirit and scope thereof.

[0016]

(Example A1)

In the example A1, a positive electrode and a negative electrode fabricated in the following manner, and a non-aqueous electrolyte solution prepared in the following manner were used to fabricate a flat coin-type lithium secondary battery as shown in Fig. 1.

[0017]

[Fabrication of Positive Electrode]

In fabricating the positive electrode, 85 parts by weight of  $\text{LiCoO}_2$  powder as a positive electrode material, 10 parts by weight of carbon powder as a conductive agent, and 5 parts by weight of polyvinylidene fluoride as a binding agent were mixed. N-methyl-2-pyrrolidone was further added to the resultant mixture to prepare a slurry. Subsequently, the above-mentioned slurry was applied to one side of the positive electrode current collector made of aluminum having thickness of 20  $\mu\text{m}$  by means of the doctor blade coating method. The slurry on the positive electrode current collector was dried at 150 °C and was then cut to

obtain a disk-like positive electrode having a diameter of 17 mm and a thickness of 1.0 mm.

[0018]

[Fabrication of Negative Electrode]

In fabricating the negative electrode, 95 parts by weight of natural graphite powder as a negative electrode material, and 5 parts by weight of polyvinylidene fluoride as a binding agent were mixed. N-methyl-2-pyrrolidone was further added to the resultant mixture to prepare a slurry. Subsequently, the above-mentioned slurry was applied to one side of the negative electrode current collector made of copper having thickness of 20  $\mu\text{m}$  by means of the doctor blade coating method. The slurry on the negative electrode current collector was dried at 150 °C and was then cut to obtain a disk-like negative electrode having the diameter of 17 mm and the thickness of 1.0 mm.

[0019]

[Preparation of Non-aqueous Electrolyte Solution]

In preparing the non-aqueous electrolyte solution, a mixed solvent containing ethylene carbonate (EC) and dimethyl carbonate (DMC) in a volume ratio of 1 : 1 was used. Lithium hexafluorophosphate  $\text{LiPF}_6$  as solute was dissolved in the mixed solvent in a concentration of 1 mol / l to prepare the non-aqueous electrolyte solution.

[0020]

#### [Fabrication of Battery]

In fabricating the battery, as shown in Fig. 1, a microporous film made of polypropylene and impregnated with the above-mentioned non-aqueous electrolyte solution was interposed as a separator 3 between the positive electrode 1 and the negative electrode 2 respectively fabricated in the above-mentioned manners, after which they were contained in a battery case 10 comprising a positive electrode connecting member 11 to which the positive electrode was connected and a negative electrode connecting member 12 to which the negative electrode 2 was connected, and the positive electrode 1 was connected to the positive electrode connecting member 11 via the positive electrode current collector 5 while the negative electrode 2 was connected to the negative electrode connecting member 12 via the negative electrode current collector 6.

[0021]

A polypropylene insulation packing 13 was provided around the positive electrode connecting member 11 and the negative electrode connecting member 12, the positive electrode connecting member 11 was bent to seal the space between the positive electrode connecting member 11 and the negative electrode connecting member 12, then the positive electrode connecting member 11 and the negative electrode connecting member 12 were electrically insulated from each



other by the insulating packing 13 to fabricate a lithium secondary battery having the diameter of 24 mm and the thickness of 3 mm.

[0022]

In the lithium secondary battery of example A1, the negative electrode connecting member 12 was fabricated by forming a nickel plating layer having the thickness of 0.002 mm outside the austenitic stainless steel of SUS316L having the thickness of 0.25 mm. As the positive electrode connecting member 11, clad material comprising aluminum 11a having the thickness of 0.05 mm and austenitic stainless steel 11b of SUS316L having the thickness of 0.20 mm, wherein the nickel plating layer 11c having the thickness of 0.002 mm was formed on said stainless steel 11b, as shown in Fig. 2, was used.

[0023]

(Examples A2 to A10)

The examples A2 to A10 were different from the example A1 only in the material of the positive electrode connecting member 11, and the austenitic stainless steel was used as the stainless steel in the clad material.

[0024]

In the example A2, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the

austenitic stainless steel 11b of SUS316L having the thickness of 0.20 mm, wherein the nickel plating layer 11c was not formed on said stainless steel 11b was used.

[0025]

In the example A3, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the austenitic stainless steel 11b of SUS316 having the thickness of 0.20 mm, wherein the nickel plating layer 11c having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0026]

In the example A4, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the austenitic stainless steel 11b of SUS304 having the thickness of 0.20 mm, wherein the nickel plating layer 11c having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0027]

In the example A5, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the austenitic stainless steel 11b of SUS304L having the thickness of 0.20 mm, wherein the nickel plating layer 11c

having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0028]

In the example A6, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the austenitic stainless steel 11b of SUS201 having the thickness of 0.20 mm, wherein the nickel plating layer 11c having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0029]

In the example A7, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the austenitic stainless steel 11b of SUS310S having the thickness of 0.20 mm, wherein the nickel plating layer 11c having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0030]

In the example A8, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the austenitic stainless steel 11b of SUS321 having the thickness of 0.20 mm, wherein the nickel plating layer 11c

having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0031]

In the example A9, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the austenitic stainless steel 11b of SUS347 having the thickness of 0.20 mm, wherein the nickel plating layer 11c having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0032]

In the example A10, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the austenitic stainless steel 11b of SUSXM7 having the thickness of 0.20 mm, wherein the nickel plating layer 11c having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0033]

Except that the positive electrode connecting members 11 comprising the above-mentioned materials were used, the same procedure as that in the example A1 was taken to fabricate each of the lithium secondary batteries of examples A2 to A10.

[0034]

(Examples B1 to B2)

The examples B1 to B2 were different from the example A1 only in the material of the positive electrode connecting member 11. Specifically, ferrite stainless steel was used as the stainless steel in the clad material.

[0035]

In the example B1, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the ferrite stainless steel 11b of SUS430 having the thickness of 0.20 mm, wherein the nickel plating layer 11c having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0036]

In the example B2, as the positive electrode connecting member 11, the clad material comprising the aluminum 11a having the thickness of 0.05 mm and the ferrite stainless steel 11b of SUS434 having the thickness of 0.20 mm, wherein the nickel plating layer 11c having the thickness of 0.002 mm was formed on said stainless steel 11b was used.

[0037]

Except that the positive electrode connecting members 11 comprising the above-mentioned materials were used, the same procedure as that in the example A1 was

taken to fabricate each of the lithium secondary batteries of the examples B1 to B2.

[0038]

(Comparative example 1)

The comparative example 1 was different from the example A1 only in the material of the positive electrode connecting member 11.

[0039]

In the comparative example 1, the positive electrode connecting member 11 was fabricated by forming the nickel plating layer having the thickness of 0.002 mm outside the aluminum having the thickness of 0.25 mm. Except for the above, the same procedure as that in the example A1 was taken to fabricate the lithium secondary battery of the comparative example 1.

[0040]

(Comparative example 2)

The comparative example 2 was different from the example A1 only in the material of the positive electrode connecting member 11.

[0041]

In the comparative example 2, the positive electrode connecting member 11 was fabricated by forming the nickel plating layer 11c having the thickness of 0.002 mm outside the austenitic stainless steel of SUS316L having the

thickness of 0.25 mm. Except for the above, the same procedure as that in the example A1 was taken to fabricate the lithium secondary battery of the comparative example 2.

[0042]

(Comparative examples a1 to a4)

The comparative examples a1 to a4 were different from the example A1 only in the material of the positive electrode connecting member 11. Specifically, martensitic stainless steel in stead of austenitic or ferrite stainless steel was used as the stainless steel in the clad material.

[0043]

In the comparative example a1, as the positive electrode connecting member 11, the clad material comprising the aluminum having the thickness of 0.05 mm and the martensitic stainless steel of SUS403 having the thickness of 0.20 mm, wherein the nickel plating layer having the thickness of 0.002 mm was formed on said stainless steel was used.

[0044]

In the comparative example a2, as the positive electrode connecting member 11, the clad material comprising the aluminum having the thickness of 0.05 mm and the martensitic stainless steel of SUS410F2 having the thickness of 0.20 mm, wherein the nickel plating layer

having the thickness of 0.002 mm was formed on said stainless steel was used.

[0045]

In the comparative example a3, as the positive electrode connecting member 11, the clad material comprising the aluminum having the thickness of 0.05 mm and the martensitic stainless steel of SUS420J1 having the thickness of 0.20 mm, wherein the nickel plating layer having the thickness of 0.002 mm was formed on said stainless steel was used.

[0046]

In the comparative example a4, as the positive electrode connecting member 11, the clad material comprising the aluminum having the thickness of 0.05 mm and the martensitic stainless steel of SUS420F2 having the thickness of 0.20 mm, wherein the nickel plating layer having the thickness of 0.002 mm was formed on said stainless steel was used.

[0047]

Except that the positive electrode connecting members 11 comprising the above-mentioned materials were used, the same procedure as that in the example A1 was taken to fabricate each of the lithium secondary batteries of the comparative examples a1 to a4.

[0048]



Each of the lithium secondary batteries in the examples A1 to A10, B1 to B2, the comparative examples 1 to 2, and a1 to a4 was charged to a charge end voltage of 4.2 V at a charge current of 100  $\mu$ A under a temperature condition of 25  $^{\circ}$ C, was then discharged to a discharge end voltage of 3 V at a discharge current of 100  $\mu$ A to find a initial discharge capacity Qo.

[0049]

Additionally, each of the above-mentioned batteries was charged to the charge end voltage of 4.2 V at the charge current of 100  $\mu$ A, was then stored for 2 months under the temperature condition of 60  $^{\circ}$ C, and thereafter, was discharged to the discharge end voltage of 3 V at the discharge current of 100  $\mu$ A under the temperature condition of 25  $^{\circ}$ C to find the discharge capacity after storage Qa.

[0050]

The percentage of capacity retention in each of the lithium secondary batteries of examples A1 to A10, B1 to B2, the comparative examples 1 to 2, and a1 to a4 was found based on the following equation. The results were shown in the following Table 1.

[0051]

The percentage of capacity retention (%) =  $(Qa/Qo) \times 100$

[0052]

[Table 1]

	material and thickness (mm) of positive electrode connecting member	percentage of capacity retention (%)
example A1	A1(0.05) + SUS316L(0.20) + Ni(0.002)	95
example A2	A1(0.05) + SUS316L(0.20)	94
example A3	A1(0.05) + SUS316(0.20) + Ni(0.002)	94
example A4	A1(0.05) + SUS304(0.20) + Ni(0.002)	90
example A5	A1(0.05) + SUS304L(0.20) + Ni(0.002)	91
example A6	A1(0.05) + SUS201(0.20) + Ni(0.002)	87
example A7	A1(0.05) + SUS310S(0.20) + Ni(0.002)	88
example A8	A1(0.05) + SUS321(0.20) + Ni(0.002)	85
example A9	A1(0.05) + SUS347(0.20) + Ni(0.002)	86
example A10	A1(0.05) + SUSXM7(0.20) + Ni(0.002)	84
example B1	A1(0.05) + SUS430(0.20) + Ni(0.002)	93
example B2	A1(0.05) + SUS434(0.20) + Ni(0.002)	92
comparative example 1	A1(0.25) + Ni(0.002)	43
comparative example 2	SUS316L(0.25) + Ni(0.002)	25
comparative example a1	A1(0.05) + SUS403(0.20) + Ni(0.002)	15
comparative example a2	A1(0.05) + SUS410F2(0.20) + Ni(0.002)	14
comparative example a3	A1(0.05) + SUS420J1(0.20) + Ni(0.002)	10
comparative example a4	A1(0.05) + SUS420F2(0.20) + Ni(0.002)	11

[0053]

As apparent from the results, each of the lithium secondary batteries in the examples A1 to A10 and B1 to B2 in which the clad material comprising the aluminum 11a and the austenitic stainless steel or ferrite stainless steel 11b was used as the positive electrode connecting member 11 to which the positive electrode 1 was connected presented a remarkably high percentage of the capacity retention and was improved in the storage characteristics of the lithium secondary batteries, compared with the lithium secondary batteries of the comparative examples 1 and 2 in which the clad material comprising the aluminum and the stainless steel was not used and each of the lithium secondary batteries of the comparative examples a1 to a4 in which the martensitic stainless steel which is neither austenitic stainless steel nor ferrite stainless steel was used as the stainless steel in the clad material.

[0054]

Each of the lithium secondary batteries of the comparative examples a1 to a4 in which the clad material comprising the aluminum and the martensitic stainless steel was used presented a remarkably low percentage of the capacity retention because the resistance of the martensitic stainless steel toward the non-aqueous electrolyte solution is much lower compared with the austenitic stainless steel and the ferrite stainless steel,

further, in the clad material comprising the aluminum and the martensitic stainless steel, a resistant alloy is not formed in the interface, thus when the aluminum inside the positive electrode connecting member 11 was damaged by the contact with the positive electrode current collector 5, the martensitic stainless steel was corroded away by the non-aqueous electrolyte solution.

[0055]

(Examples C1 to C5)

The examples C1 to C5 were different from the example A1 only in the material of the positive electrode connecting member 11. In stead of the aluminum 11a in the clad material of the example A1, an alloy comprising the aluminum and manganese was used, and in the examples C1 to C5, the amount of the manganese contained in the aluminum-manganese alloy was changed.

[0056]

Specifically, the aluminum-manganese alloy containing 0.1 wt % of the manganese in the example C1, the aluminum-manganese alloy containing 0.5 wt % of the manganese in the example C2, the aluminum-manganese alloy containing 1 wt % of the manganese in the example C3, the aluminum-manganese alloy containing 5 wt % of the manganese in the example C4, and the aluminum-manganese alloy containing 10 wt % of the manganese in the example C5 was

respectively used. Thus was fabricated each of the lithium secondary batteries of the examples C1 to C5 using the each of the positive electrode connecting members 11 formed in the same manner as the example A1.

[0057]

The percentage of the capacity retention of each of the lithium secondary batteries of the examples C1 to C5 thus fabricated was found in the same manner as the example A1. The results were shown in the following Table 2.

[0058]

[Table 2]

positive electrode connecting member: Al or Al-Mn alloy (0.05) + SUS316L (0.20) + Ni (0.002)		
	amount of Mn in Al or Al-Mn alloy	percentage of capacity retention (%)
example A1	-	95
example C1	0.1 wt %	96
example C2	0.5 wt %	97
example C3	1 wt %	98
example C4	5 wt %	96
example C5	10 wt %	96

[0059]

As a result, each of the lithium secondary batteries of the examples C1 to C5 using the aluminum-manganese alloy in the clad material for the positive electrode connecting

member 11 presented rather a higher percentage of the capacity retention compared with the lithium secondary battery of the example A1 using the aluminum, thus the storage characteristics of the lithium secondary batteries was improved.

[0060]

(Examples D1 to D4)

The examples D1 to D4 were different from the example A1 only in the type of the solute to be dissolved in the mixed solvent containing ethylene carbonate (EC) and dimethyl carbonate (DMC) in a volume ratio of 1 : 1.

[0061]

Specifically, lithium trifluoro methansulfonic acid imide  $\text{LiN}(\text{CF}_3\text{SO}_2)_2$  in the example D1, lithium pentafluoro ethanesulfonic acid imide  $\text{LiN}(\text{C}_2\text{F}_5\text{SO}_2)_2$  in the example D2, lithium trifluoro methansulfonic acid methide  $\text{LiC}(\text{CF}_3\text{SO}_2)_3$  in the example D3, and lithium trifluoro methansulfonic acid  $\text{LiCF}_3\text{SO}_3$  in the example D4 was respectively used as the solute. Each of the solutes was respectively dissolved in the mixed solvent, which was containing ethylene carbonate (EC) and dimethyl carbonate (DMC) in a volume ratio of 1 : 1, in a concentration of 1 mol / l to prepare each of the non-aqueous electrolyte solutions. Except for the above, the same procedure as that in the example A1 was

taken to fabricate each of the lithium secondary batteries of the examples D1 to D4.

[0062]

The percentage of the capacity retention of each of the lithium secondary batteries of the examples D1 to D4 thus fabricated was found in the same manner as the example A1. The results were shown in the following Table 3.

[0063]

[Table 3]

positive electrode connecting member: Al (0.05) + SUS316L (0.20) + Ni (0.002)		
	type of solute in non-aqueous electrolyte solution	percentage of capacity retention (%)
example A1	$\text{LiPF}_6$	95
example D1	$\text{LiN}(\text{CF}_3\text{SO}_2)_2$	65
example D2	$\text{LiN}(\text{C}_2\text{F}_5\text{SO}_2)_2$	62
example D3	$\text{LiC}(\text{CF}_3\text{SO}_2)_3$	60
example D4	$\text{LiCF}_3\text{SO}_3$	65

[0064]

As a result, even in a case where the type of the solute of the non-aqueous electrolyte solution was changed as the case of the lithium secondary batteries of the examples D1 to D4, when the same clad material as that in the lithium secondary battery of the example A1 was used as the positive electrode connecting member 11, the percentage

of the capacity retention was higher than that of each of the lithium secondary batteries of the comparative examples, thus the storage characteristics of the lithium secondary batteries was improved. When lithium hexafluorophosphate  $\text{LiPF}_6$  was used as the solute in the mixed solvent as the case of the lithium secondary battery of the example A1, the percentage of the capacity retention was higher, thus the storage characteristics of the lithium secondary battery was further improved compared with the lithium secondary batteries of the examples D1 to D4 using each of the above-mentioned solutes.

[0065]

(Examples E1 to E7)

The examples E1 to E7 were different from the example A1 only in the type of the solvent used in the preparation of the non-aqueous electrolyte solution of the lithium secondary battery.

[0066]

Specifically, the mixed solvent containing ethylene carbonate (EC) and diethyl carbonate (DEC) in a volume ratio of 1 : 1 in the example E1, the mixed solvent containing ethylene carbonate (EC) and ethyl methyl carbonate (EMC) in the volume ratio of 1 : 1 in the example E2, the mixed solvent containing ethylene carbonate (EC), dimethyl carbonate (DMC), and diethyl carbonate (DEC) in



the volume ratio of 4 : 3 : 3 in the example E3, the mixed solvent containing propylene carbonate (PC) and dimethyl carbonate (DMC) in the volume ratio of 1 : 1 in the example E4, the mixed solvent containing butylene carbonate (BC) and dimethyl carbonate (DMC) in the volume ratio of 1 : 1 in the example E5, the mixed solvent containing vinylene carbonate (VC) and dimethyl carbonate (DMC) in the volume ratio of 1 : 1 in the example E6, and the mixed solvent containing  $\gamma$ -butyrolactone ( $\gamma$ -BL) and dimethyl carbonate (DMC) in the volume ratio of 1 : 1 in the example E7, was respectively used to prepare each of the non-aqueous electrolyte solutions. Except for the above, the same procedure as that in the example A1 was taken to fabricate each of the lithium secondary batteries of the examples E1 to E7.

[0067]

The percentage of the capacity retention of each of the lithium secondary batteries of the examples E1 to E7 thus fabricated was found in the same manner as the example A1. The results were shown in the following Table 4.

[0068]

[Table 4]

positive electrode connecting member: Al (0.05) + SUS316L (0.20) + Ni (0.002)		
	type and volume ratio of solvent of non-aqueous electrolyte solution	percentage of capacity retention (%)
example A1	EC : DMC = 1 : 1	95
example E1	EC : DEC = 1 : 1	93
example E2	EC : EMC = 1 : 1	94
example E3	EC : DMC : DEC = 4 : 3 : 3	97
example E4	PC : DMC = 1 : 1	94
example E5	BC : DMC = 1 : 1	92
example E6	VC : DMC = 1 : 1	91
example E7	$\gamma$ -BL : DMC = 1 : 1	90

[0069]

As a result, even in a case where the type of the solvent of the non-aqueous electrolyte solution was changed as the case of the lithium secondary batteries of the examples E1 to E7, when the same clad material as that in the lithium secondary battery of the example A1 was used as the positive electrode connecting member 11, the percentage of the capacity retention was remarkably higher, thus the storage characteristics of the lithium secondary batteries was remarkably improved compared with each of the lithium

secondary batteries of the comparative examples as the case of the lithium secondary battery of the example A1.

[0070]

[Effect of the Invention]

As specifically described above, in a lithium secondary battery of the present invention, clad material comprising one of aluminum or aluminum alloy and one of austenitic stainless steel or ferrite stainless steel is used as a positive electrode connecting member to which a positive electrode is connected, therefore, the positive electrode connecting member is properly bent in order to seal fully the space between the positive electrode connecting member and a negative electrode connecting member, and moisture is prevented from coming into a battery can from a sealed portion. Further, the aluminum or aluminum alloy in the clad material is set in an inward side of the positive electrode connecting member, therefore, the positive electrode connecting member is prevented from corroding away by the non-aqueous electrolyte solution. Further, a resistant alloy is formed in an interface between one of the aluminum or aluminum alloy and one of the austenitic stainless steel or ferrite stainless steel, thus even in the case where the aluminum or aluminum alloy set in the inward side of the positive electrode connecting member is damaged for the contact with

the positive electrode current collector, the austenitic stainless steel or the ferrite stainless steel is prevented from corroding away by the non-aqueous electrolyte solution owing to the resistant alloy.

[0071]

As a result, in the lithium secondary battery of the present invention, storage characteristics is remarkably improved compared with the ordinary lithium secondary batteries, and even in a case in which cobalt-lithium oxide, nickel-lithium oxide, or manganese-lithium oxide having a spinel structure is used as the positive electrode to attain high voltage, the storage characteristics thereof was sufficient.

[Brief Description of the Drawings]

Fig.1 is a schematic sectional view of a lithium secondary battery according to examples and comparative examples of the invention.

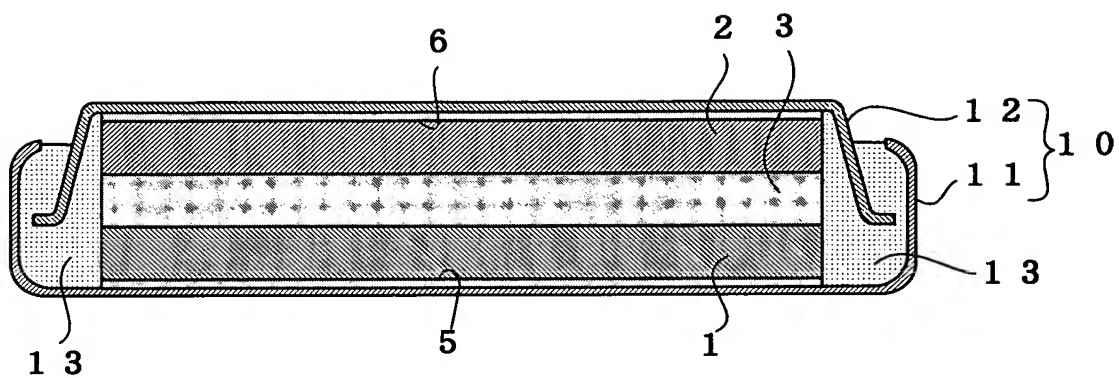
Fig.2 is a schematic explanatory view showing a state in which a positive electrode is connected to a positive electrode connecting member via a positive electrode current collector according to examples of a lithium secondary battery of the invention.

[Descriptions of Reference Numerals]

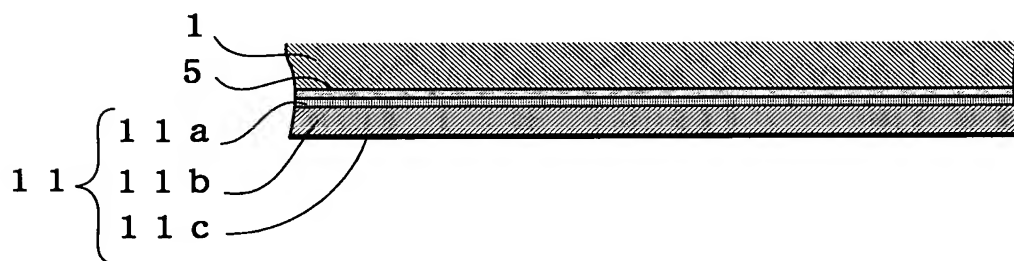
- 1 positive electrode
- 2 negative electrode

- 5 positive electrode current collector
- 6 negative electrode current collector
- 10 battery case
- 11 positive electrode connecting member
  - 11a aluminum or aluminum alloy
  - 11b austenitic stainless steel or ferrite stainless steel
- 12 negative electrode connecting member

F i g 1



F i g 2



[Name of Document] Abstract

[Abstract]

[Object]

An object of the present invention is, in a lithium secondary battery formed by placing at least a positive electrode, a negative electrode, and a non-aqueous electrolyte in a battery case wherein a positive electrode connecting member to which the positive electrode is connected and a negative electrode connecting member to which the negative electrode is connected are electrically separated, to seal a space between the positive electrode connecting member and the negative electrode connecting member and to prevent the positive electrode connecting member from corroding away by non-aqueous electrolyte solution, thus to attain the lithium secondary battery having an improved storage characteristics.

[Solution]

A lithium secondary battery is formed by placing at least a positive electrode, a negative electrode, and a non-aqueous electrolyte in a battery case 10 in which a positive electrode connecting member 11 to which the positive electrode 1 is connected and a negative electrode connecting member 12 to which the negative electrode 2 is connected are electrically separated,

wherein said positive electrode connecting member is composed of clad material comprising one of aluminum or aluminum alloy 11a and one of austenitic stainless steel or ferrite stainless steel 11b, and the aluminum or aluminum alloy is set in an inward side of the positive electrode connecting member.

[Selected Drawing] Figure 2